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ABSTRACT

This annual report of the Department of Computer and Information Science at Ohio State University for July 1977-June 1978 covers the department's organizational structure, objectives, highlights of department activities (such as grants and faculty appointments), instructional programs/course offerings, and facilities. In the second half of the report abstracts are given for 34 papers in the areas of information storage and retrieval, information analysis, programming languages, artificial intelligence, mathematical techniques, systems programming, computer architecture and networks, and computation theory. Appendices include statistical data on the growth of the University's Department of Computer and Information Science from 1973-78, a computer and information science course listing by number and title, the names of department faculty, Computer and Information Science Seminar Series presentations, related activities of and publications by the department, a listing of technical series publications since 1968, and the names of doctor of philosophy degree recipients from 1971-78. Investigator and subject indexes to the report are provided. (JD)

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ANNUAL REPORT

and

ABSTRACTS OF RESEARCH

JULY 1977 - JUNE 1978

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

Department of Computer and Information Science

The Ohio State University

Columbus, Ohio 43210

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FOREWORD

This publication contains the annual report of the Department of Computer and Information Science and abstracts of research which has been carried on during the 1977-78 academic year. This research has been supported in part by grants from governmental agencies and industry, as well as by The Ohio State University. Sponsorship with units other than the Department of Computer and Information Science is identified at the end of an abstract.

The Department of Computer and Information Science is a separate academic unit located administratively in the College of Engineering, operating in part as an interdisciplinary program with the cooperation of many other departments and colleges throughout the University. Under the department is the Computer and Information Science Research Center which is the publishing outlet for a technical report series. Research of the faculty and graduate students in the Department of Computer and Information Science is reported periodically in this series. A bibliography of the research reports published by the Center is included in this publication as Appendix G. Copies of some of these reports are still available on a complimentary basis from the Computer and Information Science Research Center,The Ohio State University, 2036 Neil Avenue Mall, Columbus, Ohio, 43210. Titles with PB or AD numbers may be obtained from The National Technical Information Center, The U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia, 22151, in paper copy, magnetic tape, or microfiche. There is a nominal charge for their service.

Marshall C. Yovits
Chairman, Department of
Computer and Information Science
July 1, 1978

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I. THE ANNUAL REPORT OF THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

Computer and information science deals with the body of knowledge concerned with the quantitative relationships, concepts, theory and methods common to the processing and utilization of information, and with the theory and operation of the systems which process information. The study of both natural and artificial languages as modes of communication and of natural and artificial systems which process information is fundamental to computer and information science. Common properties of information are induced logically by the study of specific systems and specific areas of science and technology which have a concern with the handling of information. Information is defined as data of value in decision making.

ORGANIZATIONAL STRUCTURE

The Department of Computer and Information Science is a separate academic unit located administratively in the College of Engineering, operating in part as an interdisciplinary program with the cooperation of many other departments and colleges throughout the University. The department was organized in 1960 and achieved departmental status in 1968.

OBJECTIVES OF THE DEPARTMENT

The program at The Ohio State University emphasizes education, research, service and the professional practice and application of computer and information science. The educational program offers undergraduate and graduate degrees through the Ph.D. The research activities which are a central part of the program consist of a broad conceptual base supported by a number of contracts and grants as well as by the university. The broad core research program and these other research tasks interact to form an integrated framework.

HIGHLIGHTS OF DEPARTMENT ACTIVITIES, 1977-78

The Cooperative Work Program for undergraduate majors in Computer and information science between the Department of Computer and Information Science and business and industry completed a highly successful

first year. There are 104 active undergraduate majors participating with 26 companies in the Ohio area.

First CIS Alumni Day

The Ohio State University Department of Computer and Information Science's Alumni Day was held on Thursday, May 25. Our approximately 1500 graduates were invited to return for a visit with the Department and the University. Joseph Weizenbaum of MIT was the featured speaker. He spoke on "Ethical Issues in Artificial Intelligence" and on "Computers and the Image of Man".

Enrollment in all courses was 7,528 for the four quarters of the academic year.

Degrees awarded were 8 Ph.D. degrees, 54 Masters' degrees, 125 baccalaureate degrees.

Grants:

1. Methodologies for Computer Program Testing. U.S. Airforce of Scientific Research (AFOSR 77-3416), Principal Investigators: Balakrishnan Chandrasekaran and Lee J. White.

2. Development of Information Measures and Their Application to a General Theory of Information Flow and Analysis, National Science Foundation, Division of Science Information (NSF-DSI76-21949), Principal Investigator: Marshall C. Yovits;

3. Performance Measurement Methodologies for the Design and Analysis Information Systems, National Science Foundation, (NSF-SIS75-21648), Principal Investigator: Thomas G. DeLutis;

4. Research on Data Secure Systems, Office of Naval Research, (ONR-NN0014-75-C-0573), Principal Investigator: David K. Hsiao;

5. Theoretical Research on the Translation of Phrase

Structure Languages, U.S. Air Force of Scientific Research (AFOSR 75-2811, Principal Investigator: H. William Buttelmann;

6. The Dow Chemical Fund in Compter and Information Science, Dow Chemical, U.S.A. (3527), Principal Investigators: Marshall C. Yovits, Stuart H. Zweben.

7. Early Run Time Estimation, U.S. Army Research Office (DAAG29-77-o-0185), Principal Investigator: Sandra A. Mamrak

8. Processing Systems from a DBMS and User Perspective, Army Resarch Office (DAAG29-77-o-0203), Principal Investigator: Thomas G. DeLutis;

9. The Distributed Loop Computer Network, National Science Foundation (MCS 77:23490), Principal Investigator: Ming T. Liu;

10. Properties of Axiomatic Data Specification, National Science Foundation (MCS 78-02615), Principal Investigator: Daniel J. Moore.

A new graduate program option was added as Option IX for the student specializing in hardware and software.

Faculty appointments, promotions, leave of absence, and resignations:

Thomas G. DeLutis was granted leave of absence to join a team assembled by Boling Computer Services and System Research Corporation to develop a nuclear safeguard system.

David K. Hsiao was promoted from Associate Professor of Compter and Information Science to Professor of Computer and Information Science.

Ming T.Liu was promoted from Associate Professor of Computer and Information Science to Professor of Computer and Information Science.

Charles J. Shubra, Jr. of Indiana University, Pennsylvania, was appointed as Visiting Instructor.

Norman K. Sondheimer resigned to join the staff of Sperry UNIVAC in Philadelphia, Pennsylvania.

Neelamegam Soundararajan of the TATA INSTITUTE OF FUNDAMENTAL RESEARCH, BOMBAY, INDIA was appointed as Visiting Assistant Professor.

Bruce W. Weide was appointed as Assistant Professor. He comes from Carnegie-Mellon University.

Lee J. White was promoted from Associate Professor of Computer and Information Science to Professor of Computer and Information Science.

National Recognitions

Two of our graduate students were among the four winners of the American Society for Information Science Doctoral Forum Competition. They are John S. Chandler and William S. Stalcup.

David K. Hsiao continues as editor of Transactions on Database Systems. He also continues as a member of the Governing Board of the IEEE Computer Society.

Richard E. Parent was selected as one of the four winners of the 1978 ACM Doctoral Forum.

Jerome Rothstein's paper entitled "Toward an Arithmetic for Parallel Processing" was noted the "Most Original Paper" by attendees of the 1977 International Conference on Parallel Processing, Bellaire, Michigan.

Marshall C. Yovits was elected to another 3 year term on the Computer Service Board. He continues as an elected member of the ACM Council, representing the East Central Region. He also continues as editor of Advances in Computers, a hard cover series published by Academic Press.

INSTRUCTIONAL PROGRAMS

The program of the Department of Computer and Information Science is broad and extensive. Those instructional areas which are emphasized by the Department of Computer and Information Science are as follows:

1. General theory of information
2. Information storage and retrieval
3. Theory of automata and theory of computation
4. Artificial intelligence
5. Pattern recognition
6. Computer programming, including system programming
7. Theory and processing of programming languages
8. Digital computer architecture and organization
9. Numerical analysis
10. Man-machine interaction and systems
11. Formal and computational linguistics
12. Management information and systems
13. Biological information processing
14. Social, economic, and psychological aspects of information production and processing.

The number of students enrolled in all courses was 7528. A total of 125 students received baccalaureate degrees, 54 students received the M.S. degree, and 8 students received the PH.D. degree. The number of applications for graduate study during this period was 335. Ninety-two graduate students received support from the department. There was a total of 21 full time faculty and 13 parttime faculty. For additional statistics see Appendix A.

Undergraduate Programs

Undergraduate degrees in computer and information science are available to students in the College of Engineering, the College of Mathematics and Physical Sciences of the College of Arts and Sciences, and the College of Administrative Sciences. The particular program chosen depends upon the student's interests and career objectives.

The undergraduate program in the College of Engineering leads to the degree of Bachelor of Science in Computer and Information Science. This program is designed for the student who wants to specialize in computer and information science from within an engineering environment. Hence, the program provides the student with a core of computer and information science, mathematics, and engineering science. Both depth and breadth in computer and information science

are assured by specific required course sequences in several areas of engineering and science yet, sufficient flexibility exists so that a student can elect a portion of his technical work in order to develop his individual interests.

There are two undergraduate programs in the College of Mathematics and Physical Sciences. These programs lead either to the degree of Bachelor of Science or the degree of Bachelor of Arts with a major in computer and information science. The programs are cast in a liberal arts setting and are similar in content. The Bachelor of Science program provides a somewhat more technical and thorough education in computer and information science and mathematics while the Bachelor of Arts program is somewhat more flexible and provides an opportunity to relate computer and information science to some other discipline

The undergraduate program in the College of Administrative Science leads to the degree of Bachelor of Science in Business Administration with a major in computer and information science. This program is designed for the student that is business oriented and desires an education in computer and information science and a general education in the administrative sciences. The program's objective is not to make a computer specialist out of a student, but rather to enable him to recognize the opportunities to use the computer in his managerial activities, to know what to expect from it, and to know how to communicate effectively with computer specialists so that computerized projects will be properly handled from a technical as well as a managerial point of view.

Graduate Programs

The Department of Computer and Information Science offers graduate programs leading to both the Master's and Ph.D. degrees. The graduate program leading to the Master's Degree is available in nine options.

Option I for the student desiring a theoretical foundation in computer and information science.

Option II for the student specializing in administrative systems.

Option III for the student specializing in computer systems.

Option IV for the student specializing in numerical analysis.

Option V for the student specializing in operations research.

Option VI for the student specializing in biomedical information processing.

Option VII for the student specializing in administrative science.

Option VIII for the student specializing in mathematics.

Option IX for the student specializing in hardware and software

Each of these options provides a background in several aspects of computer and information science, as well as additional mathematical sophistication appropriate to the student's interest. Each of the options may lead to the Doctoral program in computer and information science, and each may be taken with a thesis option or without a thesis option. (See Appendix B for a listing of courses by number and title.)

All courses of study at the Master's level require completion of a core program in computer and information science, together with the required courses specified for one of the options and additional courses as specified by the student's adviser. The core program includes courses on: Principles of Man-Machine Interaction, Numerical Analysis, Computer Systems Programming, Advanced Computer Programming, Digital Computer Organization, Data Structures, Mathematical Foundations of Computer and Information Science, Introduction to Linguistic Analysis, Modern Methods of Information Storage and Retrieval, and Advanced Seminar in Computer and Information Science.

The graduate program leading to the Doctoral Degree in Compter and Information Science is flexible in that it is tailored to the particular background and interests of the individual student. These interests may lie in any one of the research and instructional areas already listed as well as in many other cognate areas. A cognate field is defined as a field supporting or closely related to the fourteen Departmental fields and is ordinarily specified by an

integrated program of study in other departments of the University.

Course Offerings

Currently there are about 74 courses (each one quarter in length) offered by the Department, 19 of which are largely undergraduate with the remainder being upper level undergraduate and graduate courses. In addition to these courses there are over two hundred courses offered by a variety of departments of the University which are of interest to our graduate students who are encouraged to take these courses.

Faculty

The Department of Computer and Information Science has a full time faculty of twenty-one members at the assistant professor level and above. They have a wide range of backgrounds and experience. The above faculty is supplemented by staff who have joint appointments with other departments; by staff from other departments who teach courses primarily for Computer and Information Science students; and by adjunct staff people who are employed in off campus organizations who teach in the Department of Computer and Information Science (See Appendix C). There are currently a total of about 13 supplemental staff in this category.

FACILITIES

Computing Facilities

Computing facilities available to students are among the best in the country. The Instruction and Research Computer Center (IRCC) maintains an AMDAHL 470 V6 Model 2 with batch and timesharing terminals throughout the campus. In addition, the IRCC/CIS Computing Laboratory has a DECsystem-10 with batch and timesharing facilities, and a MICRODATA 1620 with a microprogrammable control store, which are used mainly by the Department for teaching and research. The hardware connected with the DECsystem-10 includes several CRT character terminals, a graphics CRT terminal, and a CALCOMP plotter.

The University Libraries have a university centered information services organization called the Mechanized Information Center (MIC). MIC operates as a department of the University Libraries and has both batch and online search services. The MIC batch services are unique to the OSU Libraries. There are both retrospective, or one-time, searches which provide a reveiw of the past literature, and current awareness, or updating, services which continually scan the newest literature on a regular schedule. Batch retrospective searches, covering the past three to four years, are available in science, social science, and education. Batch curent awareness services, which provide bi-weekly or monthly updates, are available in science, social sciences, and education.

MIC also offers online retrospective seaches through the facilities of three organizations outside OSU: Lockheed Information Systems, Systems Development Corporation, and the Department of Energy. There are more than 90 data bases in all subject areas covering the past two to ten or more years of literature.

Health Sciences Library

The Reference Department of the Health Sciences Library offers online searches of several biomedical data bases. MEDLINE, primarily a computerized version of index Medicus, provides coverage of worldwide medical literature. Related data bases include TOXLINe and CANCERLINE. Both retrospective and updating services are available.

Reference Department, Main Library

The Main Library Reference Department provides online searches of the New York Times INFORMATION BANK. This contains references to articles in the New York Times (back to 1969) as well as other newspapers and periodicals (back to 1972).

The Ohio College Library Center (OCLC)

The Ohio College Library Center was formed by the Ohio College Association in 1967. The Center operates a shared compterized library network connecting academic, public and school libraries in 48 states. This system has over 2100 specially designed CRT terminals in over 1600 institutions that participate on-line. The Ohio State University Libraries participate in this system and faculty of the

Department of Computer and Information Science cooperate on research projects with the Center.

INTERACTION WITHIN THE UNIVERSITY

The Department of Computer and Information Science interacts with other departments and research programs within the University because of the multidisciplinary nature of the activities encompassed in this field. A number of the academic faculty have joint appointments in other departments. Staff members of the Department of Computer and Information Science have appointments in the following departments and organizations:

a. Accounting
b. Allied Medicine
c. Art
d. Electrical Engineering
e. Engineering Graphics
f. Instruction and Research Computer Center
g. Mathematics
h. Psychology
i. University Libraries
j. University Systems Computer Center

INTERACTION WITHIN THE COMPUTER AND INFORMATION SCIENCE COMMUNITY

Columbus, Ohio is one of the major centers for information science and for the transfer of information in the United States. A number of organizations are involved with the activities of computer and information science. This affords an opportunity for students and faculty to interact with appropriate personnel in these organizations. Some of these are:

a. Chemical Abstracts Service
b. Battelle Memorial Institute
c. Bell Laboratories
d. City National Bank
e. Columbus and Southern Ohio Electric Company
f. Western Electric Corporation
g. Rockwell International Corp.
h. Industrial Nucleonics
i. State of Ohio Department of Finance: Department of Highways
j. Columbus Board of Education
k. Ohio College Library

There are a large number of scientists who come to Columbus in order to visit the Department and who usually present a seminar. (The lectures and seminars for the period of this report are listed in Appendix D). These persons

cover virtually all phases of compter and information science.

In addition, our people interact at most of the major technical meetings in this country as participants giving papers, assisting on panels, as attendees, and as officials. Hardley a major technical meeting in the appropriate fields is held without a contribution from one or more of the personnel from the Department of Computer and Information Science (CIS). A list of these activities can be found in Appendix E.

Research efforts of the staff are disseminated to the professional community through several publication channels. A list of current publications of the Department staff is included as Appendix F. In addition, the Research Center issues a technical report series (see Appendix G).

DOCTOR OF PHILOSOPHY DEGREE

The Doctor of Philosophy degree was awarded to the following students during 1977-78. See appendix H for a complete list of Ph.D. dissertations.

Name	Dissertation
Babic, Gojko	Performance Analysis of the Distributed Loop Network
Chandler, John S.	A Multi-Stage Multi-Criteria Approach to Information System Design
Cohen, David	Design of Event Driven Protection Mechanisms
Cohen, Edward I.	A Finite Domain-Testing Strategy for Computer Program Testing
Kannon, Kishnamurthi	The Design and Performance of a Database Computer

Lakshmanan, K.B.	Decision Making with Finite Memory Devices
Marik, Delores A.	Grammatical Inference of Regular and Context-Free Language
Parent, Richard E.	Computer Graphics Sculptors' Studio - An Approach to Three Dimensional Data Generation

II. INFORMATION STORAGE AND RETRIEVAL

A COMPARISON OF THE PERFORMANCE OF AVL AND ONE SIDED HEIGHT BALANCED BINARY TREES

Recent research has produced results indicating that both AVL and one-sided height-balanced (OSHB) trees have O(log n) performance characteristics, where n is the number of nodes in the tree. But the techniques developed lead to two conjectures: the actual performance of OSHB trees is inferior to that of AVL trees, and insertions in OSHB trees are more complicated than are deletions in OSHB trees. The later phenomenon would, if true, be counter to what is usually observed in data structures.

Experiments are currently being performed to investigate these conjectures. Initially, programs are being developed to implement the OSHB insertion and deletion methods proposed in previous research. Subsequently, the performance of these programs will be measured on different classes of binary trees, and compared with AVL performance studies.

S.H. Zweben

IMPLEMENTATION AND USE OF FUNCTIONS FOR EVALUATING THE EFFECTIVENESS OF AUTOMATIC VOCABULARY CONTROL TECHNIQUES

The main purpose of vocabulary control in printed keyword indexes derived from natural language text is to reduce the amount of concept scattering which would otherwise result from the many inflectional and derivational forms of words used to represent the various concepts. The intent of this research is to develop and implement an objective and quantitative method for evaluating the effectiveness of some automatic vocabulary control techniques being studied (see separate abstract). Implementation of two recently developed vocabulary control evaluation functions (VCEFs) has just been completed. As described in last year's report, one function is based on the index entropy approach and the other on index usage parameters. Use of these functions to evaluate the relative effectiveness of some stemming algorithms for automatic vocabulary control is currently in progress.

A. E. Petrarca, W. S. Stalcup

IMPLEMENTATION OF A STEMMING-RECODING ALGORITHM FOR IMPROVED VOCABULARY CONTROL IN A NATURAL LANGUAGE AUTOMATIC INDEXING SYSTEM

The objective of this research is the development and implementation of a stemming-recoding algorithm for improved vocabulary control in a natural language automatic indexing system. The algorithm developed in this research is based on approximately 500 morphological suffix removal rules, some of which were adopted from previously reported stemming algorithms; the rest originated from this research through the aid of forward and reverse lexicons generated from a 10^6 token sample (7×10^4 type sample) extracted from 10^5 natural language titles of journal articles. A character tree of approximately 2000 nodes facilitates automatic searching of the stemming rules as they are applied iteratively to successively generated word fragments. Implementation of the algorithm for improved vocabulary control in an automatic indexing system, the Double-KWIC (D-KWIC) Coordinate Indexing System, is currently in progress. Also, the effectiveness of this algorithm for vocabulary control is currently being evaluated by objective and quantitative techniques developed for this purpose (see separate abstract).

A. E. Petrarca, W. S. Stalcup

A METHODOLOGY FOR THE PERFORMANCE OF EVALUATING DATA BASE SYSTEMS

The goals of this research are 1) to formulate a methodology which characterizes data base systems for the purpose of evaluating their behavior under system usage, and 2) to provide a realization of the methodology which executes in a discrete event digital simulation environment. The methodology is specifically designed for investigating data base system behavior with respect to application processing requirements, data base software, data base organization, and data base content.

The methodology has been applied to the analysis of both network and hierarchically organized data base systems; notably a personnel data base supported by a contemporary DBMS.

Future plans include the continued enhancement of the IPSS/DBS simulator which is an implementation of the methodology, further application of the simulator to DBMS system performance; and further investigation into validation of performance evaluation methodologies.

T.G. DeLutis, J.D. Brownsmith

OPTIMAL INSERTION IN ONE-SIDED HEIGHT-BALANCED BINARY TREES

One-sided height-balanced binary trees have been proposed as an alternative to the more general AVL tree in order to avoid some of the balancing information that must be carried at each node.

It is shown that an arbitrary insertion into such a structure can be performed in $O(\log n)$ operations, where n is the number of nodes in the tree. In addition this result cannot be reduced in order of magnitude. Coupled with earlier results on one-sided height-balanced trees, it demonstrates that insertion, deletion, and retrieval in these structures can be performed in essentially the same time as the corresponding operations for AVL trees.

S.H. Zweben

GENERALIZED THEORY OF INFORMATION FLOW AND ANALYSIS

Research has been underway for a numer of years now in an effort to develop a fundamental theory of information flow and analysis. More specifically the research attempts to: (1) identify and quantify important variables and parameters in the information flow process; (2) establish relationships among these variables; (3) apply the theory to practical situations and to examine the resulting implications; and (4) develop models, both simulation and experimental, to utilize and validate the theory. We have made considerable progress along those lines and feel that we have developed the basic elements comprising an information theory. Furthermore, on the basis of our theory we have developed a powerful and flexible simulation model of information flow in a decision-making context.

We have related information to decision-making through a so-called Generalized Information System model. We have identified and defined the various uncertainties facing a decision-maker and relate information to the reduction of these uncertainties. We are able to define a Decision State and show how decision-makers will modify their Decision State by comparison between actual and expected outcomes resulting from various course of action.

We have presented a selection rule by means of which decision-makers can probabilistically select appropriate courses of action depending on their knowledge of the situation and their confidence in the available data. We show how decision-makers can learn and accordingly update their Decision State on the basis of feedback from decisions already made. Most significantly, we have established an average unique learning rule that applies to decision-makers in a given situation as a function of their particular Decision State and two parameters, confidence factor and learning factor, which characterize particular decision-makers. We have defined quantity of information, value of information, effectiveness of information, decision-maker performance, and decision-maker effectiveness and have developed unique relationships that hold on the average among these quantities, and we have developed typical curves representing the relationships. We have also determined typical average bounds on these curves. In addition to the basic theoretical work that has been accomplished, we have developed a sophisticated and flexible simulation model. The model permits us to examine the behavior of information use in a decision-making context in detail for virtually any situation of interest. Thus we have developed much of a basic theory of information flow.

There are many unsolved problems which have yet to be considered. There are a number of extensions of the theory which are quite important to consider as well as much further analysis to pursue. For example, we are examining structural uncertainty, how it should be treated, and how information relates to it. We are considering ways to incorporate negative expected values into our model. This extension is quite significant. We hope to discover and define additional measures and to determine other important relationships. Further research on deviations from the average curve is ongoing.

The theory and models presented seem to be descriptive of the decision-maing process and the way in which information is used in decision-making. It is important to establish the validity of the theory by actual experiments involving human subjects. In particular, we must determine procedures to measure the various parameters we have defined.

It is our ultimate goal to apply this theory to real and useful situations and to describe and measure the significane and value of information in these situations. We hope to apply this to information systems development, data base management systems, informatiov retrieval, and to decision systems in general.

M. C. Yovits, L. L. Rose, John J. Gavin, J. G. Abilock
(Sponsor: National Science Foundation GN: DSI 7o-21949)

IV. PROGRAMMING LANGUAGES

APPLICABILITY OF SOFTWARE SCIENCE TO WIDER CLASSES OF PROGRAMMING LANGUAGES

Investigations during the last few years have produced experimental evidence which suggests that there are surprisingly simple universal relationships governing the construction of computer programs. These studies, toward the development of a "Software Science", have generally involved a small class of reasonably similar programming languages such as Fortran, Algol, and PL/I. The objective of this research is to investigate the applicability of the techniques of Software Science to other programming languages, such as LISP and SNOBOL, which have generally different characteristics and application areas than those previously studied.

Preliminary data using LISP suggest a lack of fit of some of the Software Science relationships. Further studies are being undertaken to confirm the preliminary findings, to provide explanations for the observed behavior, and to suggest possible alternatives.

S.H. Zweben, W.E. Hall, C. Wyant

THE FREQUENCY DISTRIBUTION OF OPERATORS IN PL/I PROGRAMS

During the past few years, several investigators have noted definite patterns in the distribution of operators in computer programs, but have as yet not been able to produce a satisfactory model which explains this observed behavior over the wide range of data available.

This study concentrates on a set of production programs written in PL/I. Using some basic relationships from Software Science, and a previously published algorithm generation technique, a model is constructed which is based only on the number of distinct operators in the program, and the total number of operator occurrences.

The model provides a considerable statistical improvement over existing models for the PL/I programs studied. It is currently being subjected to further validation, and certain refinements of it are being investigated.

S.H. Zweben, The Ohio State University, M.H. Halstead, Purdue University

USING SOFTWARE SCIENCE TO EVALUATE MODULARITY IN PROGRAMMING

We consider the effects on Halstead's Software Science measures of various programming language facilities for reducing "similar" sequences of code.

Two general methods of reduction are addressed: (i) reduction of identical logical and arithmetic expressions via temporary variable definition and (ii) reduction of "similar" sequences of code via subprogram definition. In addition, an attempt is made to characterize the environments in which a particular reduction may be applicable.

It is shown that the Software Science measures appear to be appropriately sensitive to reduction of similar sequences of code; that is, changes in the measure can substantiate some of the commonly advocated "good programming style" principles concerning modular programming. In addition, aspects of techniques for measuring the Software Science parameters are discussed in the context of one's notions about various programming methodologies.

S.H. Zweben, A.L. Baker (Sponsor: Dow Chemical USA. Project No. 3527)

AN APPROACH TO MEDICAL DIAGNOSIS BASED ON CONCEPTUAL STRUCTURES

It seems to us that an experienced medical diagnostician does not have his operationally useful medical knowledge stored as collections of facts, heuristics or production rules, but rather has a knowledge organization whose very structure helps keep the combinatorial growth of processing under control. It is our thesis that the principles governing such an organization can be obtained by a careful analysis of the conceptual structure of the body of knowledge used by the diagnostician. For purposes of diagnosis, this conceptual structure is viewed as a tree, where a node stands for a particular concept and the successors of that node stand for subconcepts that help refine that concept; e.g., hepatitis, whose successors might be acute, fulminant and chronic types of hepatitis,. Associated with each node is a set of procedures, which we call action boxes and which decide on the applicability of the concept to the case at hand. Part of such decision making in a node is often the decision to turn over control to subconcepts and their associated action boxes to check on their applicability. Thus, in an abstract sense, the conceptual structure can be viewed as a way of organizing the invocation of procedures available to the diagnostician.

One of the interesting consequences of such a view is that there is a correspondence between the broad conceptual organization of a diagnostician and the organization of specialties in the medical community. The calling of a specialist by an internist is not dissimilar, in our view, to control being handed over to a subconcept in the cognitive structure of a diagnostician during the course of his problem-solving. Accordingly, it seemed appropriate to choose one of the organized specialties of medicine for such a conceptual analysis, and we chose the domain of liver diseases.

In this abstract we present , for this domain, our preliminary conceptual analysis, including the action boxes associated with the nodes. We discuss some design issues both from epistemological and implementation considerations A feeling for the potential of this approach can be obtained from our discussion of the problem-solving steps that such a system would go computer.

B. Chandrasekaran, S. Mittal, J. Smith

BUS AUTOMATON PATTERN RECOGNIZERS AND RETINAL MODELS

Earlier work on bus automata as string and pattern recognizers has been extended to perform immediate recognition and determination of topological properties of plane figures. This eliminates what is probably the greatest shortcoming of perception type models and visual systems.

J. Rothstein

GENERALIZED ENTROPY, BOUNDARY CONDITIONS AND BIOLOGY

Though most scientists feel no need to assume the existence of special "biotonic" laws for biology, consistent with, but essentially independent of physics, few claim current fundamental physics gives an adequate account of biology. We propose that generalized entropy (including the information-organization-measurement complex of ideas treated in our earlier papers) provides an adequate framework for constructing an essentially endless variety of biotonic "laws". It corresponds to freedom in design of complex systems, which is essentially like that of Turing machines or computers. Physical law underlies all designs, as with real computers. Their behavioral diversity reflects the different internal constraints, initial conditions, and boundary conditions characterizing the different systems and subsystems. Irreversibility of metabolism or evolution reflects irreversibility of measurement, subsystem preparation procedures or setting up of subsystem boundary conditions, as well as conventinal thermodynamic irreversibility; the former class involves the generalized entropy concept. Metasability, constraints, memory, information transfer, feedback and other concepts of physics, biology, cybernetics, and engineering have harmonious roles within this framework, which has essentially no ad hoc characterisitcs. All essential concepts have long been implicit or explicit in physics itself or in operationally formulatable physical methodologies. The fundamental lack in previous biophysical theorizing can be characterized as inadequate appreciation of the fundamental importance of boundary conditions (in a generalized sense) for biology; dynamical laws, rather than boundary conditions, have historically been given most attention. Goedel's incompleteness theorems and the algorithmic unsolvability of the halting problem for Turing machines lead to incompleteness theorems and undecidability results for the behavior of complex systems. These are discussed in relation to evolution, the second law of thermodynamics and other topics.

A KNOWLEDGEABLE PICTURE GENERATION SYSTEM

This research is concerned with the development of a system which includes the Knowledge Base and Picture Generation modules of a Natural Language Graphics (NLG) system (see Annual Report and Abstracts of Research, July 1976 - June 1977, p. 24). It is intended that the system should also provide some support for the natural language processing components of an NLG system. Our system will allow commands and questions, will draw and change pictures, and will, on request, output information retrieved from the stored knowledge. Whereas our previous NLG system used 2D objects (Brown 77), this system will include 3D objects. Knowledge about the parts and construction of objects will be stored in the system, and will be used for both generation of pictures and answering questions.

The development of a suitable representation language for the description of objects underlies this research, and has been described elsewhere (see abstract "Knowledge Representation Language Development" in this report). We expect that advances will be made in both representation language design and in the representation of objects. We will be representing objects in terms of object primitives, and not, as is usually the case in Computer Graphics, with graphical primitives, such as lines. The interpretation of the object primitives is both device-dependent and graphical output method dependent (e.g. wire-frame vs. shading).

For picture generation we have chosen to use standard techniques from Computer Graphics, but to implement them in an explicit way that separates the various coordinate systems and transformations. This will allow representation of an object in the abstract, in a 'world' with other objects, with a view imposed, in a viewed 2D form, and in a device-dependent form. This separation allows the processing of questions about each of these levels. For example, "which things support other things" is important at the world level but not at the screen level, whereas for "which lines connect with which other lines" exactly the opposite is true. Using this organization we will not only provide a question-answering capability in the system -- itself an unusual, and, we suspect, very useful facility -- but we will allow the system to have knowledge of the things being drawn on the output device, thus allowing improved person-machine interaction.

The system is being implemented in LISP 1.6 on a DECsystem-10 computer, using a Plasma Panel and Plotter as output devices. Support for the system -- including the representation language system and basic knowledge -- occupies about 20k words, and the addition of object description will probably double that figure.

This research provides a foundation for an NLG system, investigates knowledge-based picture production, and is concerned with improving person-machine interaction by allowing a blend of question-answering and graphics, and by considering the things displayed on the output device as objects as well as pictures. We expect that contributions will also be made in the areas of representation language design and the representation of objects.

B. Chandrasekaran, D. C. Brown (Sponsor:French Fellowship)

KNOWLEDGE REPRESENTATION LANGUAGE DEVELOPMENT

This research is concerned with developing and implementing a computer language for representing knowledge. The language is intended to be general-purpose, but is being specifically developed for the representation of objects in the Knowledge Base component of a Natural Language Graphics (NLG) system (see Annual Report and Abstracts of Research, July 1976-June 1977, p. 24.)

The representation system is based on object-centered declarative information-units which we call 'chunks'. Chunks can be expressed in the language and can be formed into generalization hierarchies, storing at each level information which is common to all objects at lower levels. Chunks at the lowest level represent individual objects. Defaults and procedural attachment can be used to provide both context free and context sensitive default values for those values which are required but have yet to be specified.

Access to and manipulation of the stored knowledge is provided by several levels of user functions; the lowest providing access to small sections of chunks, and higher levels providing searching capabilities. Execution of some functions may trigger actions attached to chunks higher in the hierarchy, and these actions may themselves act on chunks, or interact with the user to check or provide values.

The language is being implemented in LISP 1.6 on the DECsystem-10 computer. The total language system occupies about 10k words at present, but will increase as more capabilities are added. However, not all of the system is required to be in the memory at the time the chunks are being used, and we expect the 'run-time' storage requirement to be more reasonable.

The language design is almost stable, with all major components having been implemented. As the language is being used (see abstract "A Knowledgeable Picture Generation System" in this report) we expect to make modifications and additions as necessary.

B. Chandrasekaran, D. C. Brown (Sponsor: French Fellowsnip)

A PERCEPTION BASED, DEVELOPMENTAL SKILL ACQUISITION SYSTEM

In this research, the objective is a methodology for the design of a robot system which is capable of being taught. This supplants the traditional objective of building a robot which is "omnipotent." A human master given new skills (action-schemas) to the robot when needed. In so doing he also implicitly transfers his knowledge about the world in a different form. Initially, the robot has no skills and almost no knowledge. In short, the robot develops in its abilities and in its "understanding."

Skilled behavior is perception-controlled. Any such behavioral pattern is reducible into a sequence of bodily movements, each initiated and terminated by a perceived situation in the world and not by any hypothetical situation in a world model. When skills defined by a master are used exclusively almost no hypothetical world model is needed, hence the hard problem of keeping a model consistent with reality has been greatly reduced. A mini language has been designed which allows a master to build, from chosen bodily movements, perceptual abilities (taken for granted) and previously defined skills, a new skill using feedback, hierarchy and recursion.

A simulation for the robot is being built on a graphics terminal using a hypothetical world of a 3-floor building.

B. Chandrasekaran, H. Jappinen

STRAIGHT LINE PATTERN RECOGNITION WITH CELLULAR AUTOMATA

The work described last year has been extended and is being organized into a dissertation. As stroke notation for numbers is cumbersome, we were not satisfied with achieving immediate parallel performance of all needed statistical computations in that notation. We sought and found fast parallel algorithms for conversion between stroke and binary number systems, found a parallel algorithm for binary addition and an "almost immediate" algorithm for binary multiplication. The number of steps needed, if n is the smaller of the two factors being multiplied, is the k-fold iterated log function (to base 2), where k is the smallest number of iterations to reduce $g(n) = \log_2 \ldots \log_2 n$ to no more than 2.

J. Rothstein, J. Mellby

TRANSITIVE CLOSURE, PARALLELISM, AND THE MODELING OF SKILL ACQUISITION

A frequent component of skill acquistion is increased speed in carrying out procedures, another the ability to coordinate tasks simultaneously (in parallel) rather than successively (sequentially). Finite state input-output performance models, though useful descriptively and conceptually, need better than ad hoc patching up to exhibit increased speed, increased ability to handle complexity, and a structural basis for learning plateaus. This research uses the notions of transitive closure and parallelism in a natural way to construct generalizations of finite state models with these characteritics. They seem compatible with curent knowledge of both human performance and the structure of the sensori-neuromuscular systems, and permit progressive development from simple sequentiality to the maximum speed and parallelism possible with any assigned bounds on the numbers and capacities of input and output channels, and of memory. The full gamut of computational complexity, rather than regular operations alone, becomes accessible, with significant speed-up possible in the most general case. Essential use is made of the bus automaton concept. (see: Proceedings of the 1976 Interntional Conference on Parallel Processing, Bellaire, Michigan, pp. 206-212)

J. Rothstein

UNGRAMMATICALITY IN NATURAL LANGUAGE PROCESSING SYSTEMS

This study focuses on techniques to allow the processing of ungrammatical forms in a Natural Language Processing System. A normative grammar is used to guide parsing so as to allow grammatical forms primarily and ungrammatical forms secondarily.

Techniques have been developed within the Augmented Transition Network (ATN) formalism for allowing relaxation of tests and categories in the grammar, for interfacing the use of patterns and keywords with the grammar, and for providing expectations based on lexical entries.

The usefulness of the techniques described above has been verified. Implementation has begun of a moderate size grammar aimed at robust language processing.

A habitable, working system which is capable of handling grammatical as well as a wide variety of ungrammatical forms should be demonstratable in the near future.

S. C. Kwasny; N. K. Sondheimer

APPROXIMATE FACTORIZATION PROCEDURES

The numeral solution of boundary value problems for elliptic partial differential equations in two and three dimensions by finite difference methods customarily requires the solution of a set of linear equations of very large order in which the matrix is very sparse. One class of methods for solving such problems is that of the approximate factorization procedures. Our work involves the study of a new addition to this class of methods based on Cholesky's method. In particular, we are concerned with aspects of its practical implementation and application and with understanding its convergence properties when combined with the conjugate gradient method.

R. Underwood

BINARY STRINGS AND GEOMETRY

The possible use of a binary language originally created for straight lines to describe curves in curvilinear coordinate systems, has been carried out explicitly. For the case of isotnermal coordinates in the plane (given by conformal mappings) the group involved has even been broadened to an affine-conformal group. Work on the special analytical transformation $w = z$, which leads to treating parabola recognition under the above rubric in confocal parabolic coordinates, has been started, the goal being a bus automaton implementation of both the coordinate transformation and parabolic recognition.

J. Rothstein, A. Davis

NUMBER TREES, SEMIGROUPS, AND FORMAL LANGUAGES

Consideration is being given to how numerical algorithms might be related to number trees. In particular, the famous "3x + 1 problem" has been shown to be equivalent to asserting that the algorithm involved locates all the natural numbers on a single number tree. This problem can be stated as proving (or disproving) the following: all natural numbers can be reduced to unity by a finite number of steps of the following two kinds (a) if the number is even, divide by 2 and b) if the number is odd, replace it by one plus three

times the number. It is also equivalent to existence (or non-existence) of a novel kind of representation for the integers.

J. Rothstein

AN OPTIMALLY CONDITIONED HYBRID ALGORITHM FOR UNCONSTRAINED OPTIMIZATION WHICH MAINTAIN THE UPDATE MATRIX IN FACTUAL FORM

Given a function f(x) which maps from R^n to R the unconstrained optimization problem is to find the point x* at which f(x) attains its minimum. One of the most successful class of algorithms for this problem is the quasi-Newton method which is iterative and takes the form $x_{K+1} = x_K - \lambda_K H_K g_K$. Where λ_K is a scalar, $g_K = g(x_K) = \nabla f(x_K)$ is the gradient of f(x) at x_K and H_K is an n by n matrix approximating the inverse of the Hessian of f at x_K.

A FORTRAN subroutine has been developed which is a new version of the earlier primitive subroutine MINOP (Dennis and Mei 1977). This routine uses the double dogleg strategy to select search directions and uses Davidon's 1975 Optimally Conditioned update H_K while maintaining it in the Cholesky factionization form of LDL^T using Householder transformation. A total of $n((n+1)/2+1)$ array storage is needed which is essentially only ½ of the original MINIP.

H. H. Mei

A STUDY OF MULTIPLE CLOSURE EQUATIONS IN NUCLEAR SAFEGUARDS MEASUREMENT SYSTEMS

To fully use the system of closure equations generated to describe and control a high-throughput mixed-oxide (4% PuO2 in UO2) process, a procedure was developed to formally integrate the effect of both short-term and long-term closure equations into an overall system criterion of performance. The objective is to maximize the detection sensitivity within a given detection time period. In this assessment of the value of using multiple closure equations , the following situations were accounted for:

1. The combination of independent nonoverlapping closure

equations to obtain an overall performance criterion;
2. Possible overlap between several closure equations;
3. Possible correlated variables between different closure equations.

Both single and multiple diversion strategies are examined in order to show how the controllable unit approach (CUA) method can protect against either strategy. Quantitative results show that combined closure equations improve the detection senstivity to material loss, and that multiple diversions provide only diminishing returns for the potential divertor even without taking into account the increased risk and logistic difficulty.

L.J. White, The Ohio State University, P.W. Seabaugh, Monsanto Corporation (Sponsor: Mound Research Laboratory, Monsanto Research Corporation)

TREE PERMUTATIONS

There are several classes of permutations of n distinct elements which have nice relationships to binary trees containing n nodes. For example, if p is a permutation of n distinct elements 1,....,n, then the number of such permutations for which there is no subsequence $p_i p_j p_k$ of p such that $p_k < p_i < p_j$ is exactly the number of binary trees containing n nodes. Moreover, the same result holds for any permutation of p_i, p_j, and p_k in the condition "$p_k < p_i < p_j$". For four of these six permutation classes, the correspondence can be given using well-known methods of binary tree traversal. But there has been no simple, direct correspondence for the classes "$p_i < p_j < p_k$" and "$p_k < p_j < p_i$".

Two correspondences for the latter set of permutations have been investigated. The more interesting of the two is based on the natural correspondence between binary trees and forests. A proof of the relationship has been developed, and consequences of the correspondence are being investigated.

As for the former set of permutations, there is as yet no relationship more insightful than that obtained by reversing the permutations gotten from the former set.

S.H. Zweben

TRENDS IN NUMERICAL COMPUTATION

New kinds of computers are now being proposed and constructed. These new hardware configurations which provide various kinds of parallel, distributed, and special purpose computing capabilities, are changing the "rules" of the game. Our work is concerned with assessing the impact of these new types of hardware on numerical computing. Furthermore, as the cost of hardware continues to decrease, the constrructin of computers specially adapted to the solution of particular numerical problems such as weather prediction is becoming more feasible economically. Our work is also concerned with suggesting what types of capabilities might be included in such computers.

R. Underwood

COMPUTER SYSTEM SELECTION

Studies for computer system selection lack a comprehensive scientific methodology which leads to the selection of the best computer system and at the same time provides a statistical confidence statement of having made the correct choice. Statistical ranking and selection techniques, which have been recently applied to some stages of this selection process with considerably initial success, provide the foundation for the needed methodology. There are, however, some differnces between the requirements of the statistical techniques as they are currently exist and the properties present in computer comparison data. This research proposes to resolve these differences which arise from certain data independence and data distribution assumptions, thus making a step towards moving from initial promising beginnings to a comprehensive scientific methodology for compter system selection. The final outcome of this effort will be a step-by-step description of the application of ranking and selection techniques to the compter selection process.

S. A. Mamrak, P. D. Amer; M. D. Abrams, National Bureau of Standards.

DOMAIN STRATEGY FOR COMPUTER PROGRAM TESTING

Computer programs contain two types of errors which have been identified as transformation errors and domain errors. A domain error occurs when a specific input follows the wrong path due to an error in the control flow of the program. A path contains a transformation error when a specific input follows the correct path, but an error in some assignment statement causes the wrong function to be computed for one or more of the output variables. A testing strategy has been designed to detect domain errors, and the conditions under which this strategy is reliable are given and characterized. It is the objective of this study to provide an analytical foundation upon which to base practical testing implementations.

There are limitations inherent to any testing strategy, and these also constrain the proposed domain strategy. One such limitation might be termed coincidental correctness, where if a specific test point were to follow an incorrect path, the output variables would coincidentally be the same as if that test point were to follow the correct path. Another limitation has been previously identified as a

missing path error, in which a required predicate does not appear in the given program to be tested.

The testing strategy generates test points to determine whether the boundaries of a domain corresponding to a specific path have shifted. The strategy is shown to be reliable in detecting domain errors to within the resolution of how close to a boundary the test points can be selected, and this result is valid subject to the following assumptions:

(1) coincidental correctness does not occur;
(2) missing path errors do not occur;
(3) predicates are linear in the input variables.

Assumptions (1) and (2) are inherent to the testing process, and cannot be entirely eliminated. The method has been shown to be applicable for nonlinear boundaries, but this will increase the number of required test points and leads to considerable complexity. Consider futher assumptions:

(4) predicates are simple; and
(5) adjacent domains compute different functions.

If assumptions (4) and (5) are also imposed, the testing strategy is considerably simplified as no more than one domain need be examined at one time in order to select test points. Moreover, the number of test points required to test each domain grows linearly with both the dimensionality of the input space and the number of predicates along the path being tested.

L.J. White, E. Cohen, B. Chandrasekaran (Sponsor: Air Force Office of Scientific Research. Grant 77-3416)

PROPERTIES OF AXIOMATIC DATA SPECIFICATION

Properties of the process of axiomatic specification of abstract data types are being studied. Development of this approach to data specification has been judged important for the future of programming methodology in spite of inherent problems.

Properties of primitive data types, such as completeness

of their specifications, appropriate axiomatizations, types of models, and correctness of implementations are being catalogued. The use of those primitive types in constructing user - defined data types are being investigated, and the properties the new types may possess are being explored. The possibility of automatic completeness checking and implementation by compiler are being evaluated.

It is anticipated that this research will answer many of the questions concerning the utility of axiomatic data specification, and establish it as an important method of data description.

D. Moore (National Science Foundation - Grant 71-1217)

VIII. COMPUTER ARCHITECTURE AND NETWORKS

ANALYSIS AND SIMULATION OF THE DISTRIBUTED LOOP COMPUTER NETWORK

This research is concerned with a performance study of the Distributed Loop Computer Network (DLCN) through queueing analysis and simulation.

Previous research on DCLN has concentrated on the loop interface design, message protocol and network operating system, all of which have not been validated against real hardware or an analytic model. The objectives of the proposed research are therefore to accomplish the latter and can be broken down as follows:

1) to study an analytic model of DLCN as an open cyclic queueing network,
2) to obtain design parameters, such as data block and record size, buffer size, line utilizazation, message delay, system through put, etc., for real hardware implementation of DLCN later on,
3) to verify superior performance of DLCN over other types of loop networks, and
4) to validate analytic results throgugh computer simulation using GPSS and running on IRCC's 370/168 computer.

M. T. Liu, G. A. Babic (OSU Graduate School Small Research Grant No. 221110)

THE DISTRIBUTED LOOP COMPUTER NETWORK (DLCN)

Conceived as a means of investigating fundamental problems in distributed processing and local networking, the Distributed Loop Computer Network (DLCN) is envisioned as a powerful distributed processing system which interconnects small- and medium-scale computers, terminals and peripherals through careful integration of hardware, software and a loop communication subnet. Previous research concerning DLCN has concentrated on the loop communication subnet, message protocol, network operating system and network command language.

This project is implementing an exoerimental 3 mode interconnection of existing computers in order to study loop reliability and to experimentally verify results of previous simulation studies. In addition the analytic modelling and performance study of network is being considered.

M. T. Liu, R. Pardo, T. P. Tsay, J. J. Wolf (National Science Foundation Grant No. MCS-77-23496)

DISTRIBUTED PROCESSING ALGORITHMS

A Distributed Processing Algorithm (DPA) is an algorithm whose execution involves interaction between two or more remote processes in a distributed processing system. Most of software issues in distributed processing systems are related to the concept of DPAs. One important aspect is the message exchange (protocol) requirements induced by the DPAs. Current high-level communication protocols efficiently support the establishment, maintenance, and termination of connections between two processes, and thus can be called 2-process communication protocols. However, this class of protocols limits the type of DPAs that can be efficiently supported by a distributed processing system. In this paper we propose a class of protocols that are not constrained to handle only 2-process communication but rather any "network of connections," and we refer to a protocol in this class as an N-process communication protocol. The purpose of this research is to motivate the need for such protocols, to show their relationship with distributed processing systems, and to establish their features.

M. T. Liu, R. Pardo, G. A. Babic (Sponsor: Air Force Office of Scientific Research, Grant 77-3400)

FORMAL SPECIFICATIONS OF COMMUNICATION PROTOCOLS

This research is concerned with a formal model using the context-free grammar (CFG) for the design and implementation of communication protocols. It is similar to the Backus-Naur Form that has been used to define the snytax of programming languages. A transmission grammar (TG) is used to define the protocol for a communication entity (e.g., a hardware modem, interface processor, host computer, or user process). For the layered protocol design, the communication entity of each layer is decomposed into more detailed inner-layered components or logically independent parts (e.g., the sender and receiver). The local approach is first used to define the TGs for all the decomposed components and logical parts. The shuffle and substitution operations are then applied to integrate the TGs of the logical parts and the TGs of the components, respectively. The IMP level protocol of the ARPANET is used as a working example to illustrate the

grammartic property of protocols and the design methodology of IGs. In addition, comparisons with other formal models and techinques for logical validation and automatic implementation are considered.

M. T. Liu, A. Y. Teng (Sponsor: Air Force Office of Scientific Research, Grant 77-3400)

AN OPTIMUM NETWORK LOCATION PROBLEM

Many problems in the design of cost effective networks involve the optimal location of allocation of certain resources to sites in the network and are combinatorial in nature. We have considered two such network problems:

(1) the optimal file allocation problem in a distributed computer network, and
(2) the optimal concentrator location problem which arises in the design of centralized computer or communication networks.

Both of these problems can be modelled by a graph G(V,E) in which both nodes and edges are weighted. Consider a dominating set to be a subset of D (transmitters) of vertices in V and a subset L (links) of the edges in E such that every vertex is either a transmitter or adjacent to a transmitter by a link in L. The problem of optimum domination is to find D and L such that the total cost of transmitters in D and links in L is a minimum.

This problem has been shown to be NP-complete, and thus it is unlikely that there is an efficient solution for the general problem for an arbitrary graph. However, we have developed an algorithm which is linear in the number of vertices V_e to solve the optimum domination problem for the special case of a tree.

Current work is directed toward the development of a heuristic method for solving the optimum domination problem for an arbitrary graph by utilizing the domination for trees. Experimental work will determine the effectiveness of this approach for both optimal file allocation and optimal concentrator location problems.

L. J. White, K. S. Natarajan

TOWARD AN ARITHMETIC FOR CELLULAR AUTOMATA AND PARALLEL COMPUTATION

Several significant new results have been obtained in the past year. First, a completely parallel algorithm for obtaining entire new octaves of numebers, in order, from their predecessor octaves has been worked out for bus automaton implementation. Second, the bus automaton display of those integers has been utilized in a parallel algorithm computing all the binomial coefficients of any order simultaneously. Third, the bus automaton operation itself has been turned into a parallel method of generating an unlimited number of combinatorial identities between binomial coefficients, Each identity is characterized by its geometrical pattern on the planar bus automaton. Rigid translation of the pattern in the plane varies the parameters n and r of the various $\binom{n + a_i}{r + b_i}$ coefficients involved in the identity. Here a_i and b_i are a set of fixed constants which can be viewed as the "relative coordinates" of the binomial coefficients involved in the identity with respect to the reference (n, r). The significance of these results for combinatorics, combinatorial geometry, and automated theorem-proving is obvious. Combining them with previous and on-going work on the application of bus automata to pattern and language recogition, the modeling of skill acquisition, and modeling of visual and nervous systems, generates hopeful expectation of real progress in understanding the nature of intelligence and how to endow machines with it.

J. Rothstein

APPENDIX A

GROWTH OF DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

	SEPT'73	SEPT'74	SEPT'75	SEPT'76	SEPT'77	SEPT'78
A. Staff						
1. Full Time	18	20	21	22	20	21
2. Part Time	16	12	12	12	13	12
B. Graduate Students	209	198	201	182	197	198(est)
C. Undergraduate Students	510	475	450	470	470	470(est)
D. Course Enrollment (Autumn Quarter)	1728	1925	2098	2290	2308	2350(est)

	'73-74	'74-75	'75-76	'76-77	'77-78
Students Taught	6129	6876	7241	7615	7528
Baccalaureate Degrees Awarded	139	109	103	118	125
M.S. Degrees Awarded	67	58	64	70	54
Ph.D. Degrees Awarded	4	7	13	5	8
Ph.D. Degrees Awarded-Total	16	23	36	41	49
Applications for Graduate Study	290	355	325	333	335
Number of Graduate Students Supported	78	81	77	81	92

APPENDIX B

COMPUTER AND INFORMATION SCIENCE COURSE LISTING

BY NUMBER AND TITLE

100 Computers in Society

201 Elementary Digital Computer Programming

211 Computer Data Processing I

212 Computer Data Processing II

221 Programming and Algorithms I

222 Programming and Algorithms II

294 Group Studies
294B File Processing I
294C File Processing II

311 Introduction to File Design and Analysis

411 Design of On-Line Systems

505 Fundamental Concepts of Computer and Information Science

509 Survey of Computer and Information Science for High School Teachers

511 Computer Systems and Programming for Administrative Sciences

541 Survey of Numerical Methods

542 Introduction to Computing in the Humanities

543 Intermediate Digital Computer Programming

548 Computer Science for High School Teachers

550 Introduction to Information Storage and Retrieval

555 Survey of Programming Languages

610 Principles of Man-Machine Interaction

640 Numerical Analysis

641 Computer Systems Programming I

642 Numerical Linear Algebra

643 Linear Optimization Techniques in Information Processing

644 Systems Programming

675 Digital Computer Organization

676 Minicomputer and Microcomputer Systems

677 Computer Networks

680 Data Structures

693 Individual Studies

694 Group Studies

694 J - Data Models and Database Systems

705 Mathematical Foundations of Computer and Information Science

712 Man-Machine Interface

720 Introduction to Linguistic Analysis

726 Theory of Finite Automata

727 Turing Machines and Computability

728 Topics in Theory of Computing

730 Basic Concepts in Artificial Intelligence

735 Statistical Methods in Pattern Recognition

740 Computer Systems Programming II

741 Comparative Operating Systems

745 Numerical Solution of Ordinary Differential Equations

746 Advanced Numerical Analysis

750 Modern Methods of Information Stor[illegible] & Retrieval

751 Fund[illegible]ls of Document-Handling Information Systems

752 Techniques for Simulation of Information Systems

753 Theory of Indexing

754 Language Processing for Information Storage & Retrieval

755 Programming Languages

756 Compiler Design & Implementation

765 Management Information Systems

775 Advanced Computer Organization

780 File Structures

781 Aspects of Computer Graphics Systems

788 Intermediate Studies in Computer & Information Science

788.01 - Theory of Information

788.02 - Information Storage & Retrieval

788.03 - Theory of Automata

788.04 - Artificial Intelligence

788.05 Pattern Recognition

788.06 Computer Systems Programming

788.06A Computer Center Organization and Management

788.07 - Programming Languages

788.08 - Computer Organization

788.09 - Numerical Analysis

788.10 - Man-Machine Interaction

788.11 - Formal Languages

788.12 - Management Information Systems

788.13 - Biological Information Processing

788.14 - Socio-Psychological Aspects of Information Processing

793 Individual Studies

797 Interdepartmental Seminar

805 Information Theory in Physical Science

806 Cellular Automata & Models of Complex Systems

812 Computer & Information Science Research Methods

820 Computational Linguistics

835 Special Topics in Pattern Recognition

845 Numerical Solution of Partial Differential Equations

850 Theory of Information Retrieval I

852 Design and Analysis of Information Systems Simulations

855 Advanced Topics in Programming Languages

865 Seminar on Socio-Psychological Aspects of the Information Sciences

880 Advanced Theory of Computability

888 Advanced Studies in Computer & Information Science

888.01 - Theory of Information

888.02 - Information Storage & Retrieval

888.03 - Theory of Automata

888.04 - Artificial Intelligence

888.05 - Pattern Recognition

888.06 - Computer Systems Programming

888.06A- Topics in Computer Correctness

888.07 - Programming Languages

888.08 - Computer Organization

888.09 - Numerical Analysis

888.10 - Man-Machine Interaction

888.11 - Formal Languages

888.11A- Advanced Seminar in Computer and Information Science

888.12 - Management Information Systems

888.13 - Biological Information Processing

888.14 - Socio-Psychological Aspects of Information Processing

889 Advanced Seminar in Computer & Information Science

894 Group Studies

899 Interdepartmental Seminar

999 Research

APPENDIX C

COMPUTER AND INFORMATION SCIENCE FACULTY

Marshall C. Yovits, Ph.D., (Yale University).
Professor and Chairman of Department of Computer and Information Science and Professor of Electrical Engineering. Director, C.I.S. Research Center. Information systems, theory of information flow and analysis, self-organizing systems, management information systems.

Ranko Bojanic, Ph.D., (Mathematical Institute of the Serbian Academy of Science).
Professor of Computer and Information Science and Professor of Mathematics. Mathematical analysis, theory of approximation.

Balakrishnan Chandrasekaran, Ph.D., (University of Pennsylvania).
Professor of Computer and Information Science. Pattern recognition, artificial intelligence, interactive graphics, finite memory decision theory.

Charles A. Csuri, M.A., (The Ohio State University).
Professor of Computer and Information Science and Professor of Art. Advancement of computer graphics technology in software and hardware (language algorithms, data generation or inputs), use of computer technology in telecommunications.

Richard I. Hang, M.A., (The Ohio State University).
Professor of Computer and Information Science and Professor of Engineering Graphics. Computer graphics, engineering application of computers.

David K. Hsiao, Ph.D., (University of Pennsylvania).
Professor of Computer and Information Science. Systems programming, computer architecture, data base management systems, access control and privacy protection of data, data base computers.

Clyde H. Kearns, M.S., (The Ohio State University).
Professor of Computer and Information Science and Professor of Engineering Graphics. Computer graphics, engineering application of computers.

Robert D. LaRue, P.E., M.S., (University of Idaho).
Professor of Computer and Information Science and Professor of Engineering Graphics. Computer graphics, engineering applications of computers.

Ming-Tsan Liu, Ph.D., (University of Pennsylvania).
Professor of Computer and Information Science. Computer architecture and organization, computer communications and networking, parallel and distributed processing, mini/micro computer systems.

Robert B. McGhee, Ph.D., (University of Southern California).
Professor of Computer and Information Science and Professor of Electrical Engineering. Robotics, switching theory, logical design.

Roy F. Reeves, Ph.D., (Iowa State University).
Professor of Computer and Information Science and Professor of Mathematics. Director, Instruction and Research Computer Center. Numerical analysis, programming, computer center management.

Jerome Rothstein, A.M., (Columbia University).
Professor of Computer and Information Science and Professor of Biophysics. Information and entropy, foundations of physics, methodology, biocybernetics, automata theory, formal languages, cellular automata, parallel processing.

Charles Saltzer, Ph.D., (Brown University).
Professor of Computer and Information Science and Professor of Mathematics. Coding theory, numerical analysis, automata theory.

Lee J. White, Ph.D., (University of Michigan).
Professor of Computer and Information Science and Associate Professor of Electrical Engineering. Algorithm analysis and complexity, data structures, organization of information.

Kenneth Breeding, Ph.D., (University of Illinois).
Associate Professor of Computer and Information Science and Associate Professor of Electrical Engineering. Computer organization and switching theory.

H. William Buttelmann, Ph.D., (University of North Carolina).
Associate Professor of Computer and Information Science. Formal language theory, computational linguistics, language processing, programming languages.

Thomas G. Delutis, Ph.D., (Purdue University).
Associate Professor of Computer and Information Science. Methodologies for the design and evaluation of information processing systems, data base management systems architecture, simulation studies.

Ronald L. Ernst, Ph.D., (University of Wisconsin).
Associate Professor of Computer and Information Science and Associate Professor of Psychology. Man-computer interaction, decision-systems, general theory of human performance.

Clinton R. Foulk, Ph.D., (University of Illinois).
Associate Professor of Computer and Information Science. Systems programming, computers in education.

Douglas S. Kerr, Ph.D., (Purdue University).
Associate Professor of Computer and Information Science. Programming, data base systems, numerical analysis.

Anthony E. Petrarca, Ph.D., (University of New Hampshire).
Associate Professor of Computer and Information Science. Automatic indexing, chemical structural information processing, automated search systems, other aspects of information storage and retrieval, biomedical information processing.

James B. Randels, Ph.D., (The Ohio State University).
Associate Professor of Computer and Information Science and Assistant Director, University Systems Computer Center. Computer operating systems and utilities, telecommunications applications, subroutine libraries, programming languages.

James E. Rush, Ph.D., (University of Missouri).
Adjunct Associate Professor of Computer and Information Science. Indexing theory, automated language processing, organization of information, parallel processing, structured programming, program testing and program management.

Celianna I. Taylor, B.S.L.S., (Graduate School of Library Science, Case-Western Reserve University).
Senior Research Associate and Associate Professor of Library Administration. Data base design (natural language data), information dissemination systems, information centers, library systems and management.

Ronald L. Wigington, Ph.D., (University of Kansas).
Adjunct Associate Professor of Computer and Information Science and Director of R. & D., Chemical Abstracts Service. Computer and information system design.

Ramamoorthi Bhaskar, Ph.D., (Carnegie-Mellon University). Appointed Autumn 1978.
Assistant Professor of Computer and Information Science and Assistant Professor of Accounting.

Sandra Mamrak, Ph.D., (University of Illinois).
Assistant Professor of Computer and Information Science. Computer system performance evaluation, computer networks, systems programming.

Howell H. W. Mei, Ph.D., (Cornell University).
Assistant Professor of Computer and Information Science. Nonlinear optimization, nonlinear systems of equations, operating systems design, algorithm design.

Daniel J. Moore, Ph.D., (University of Kansas).
Assistant Professor of Computer and Information Science. Complexity theory, recursion theory, semantics of simulation systems, formal theories of data abstraction.

Richard E. Parent, Ph.D., (The Ohio State University). Appointed Summer 1978.
Adjunct Assistant Professor of Computer and Information Science and Associate Director Computer Graphics Research Group.

Kevin C. O'Kane, Ph.D., (Pennsylvania State University).
Assistant Professor of Computer and Information Science and Assistant Professor of Allied Medical Professions. Coordinator, Graduate Training Program in Biomedical Computing and Information Processing. Biomedical computing, large medical data bases, clinical data acquisitions, automated diagnosis.

Lawrence L. Rose, Ph.D., (Pennsylvania State University).
Assistant Professor of Computer and Information Science. Programming languages, information storage and retrieval, simulation, information theory.

Norman K. Sondheimer, Ph.D. (University of Wisconsin)
Assistant Professor of Computer and Information Science. Natural language processing, artificial intelligence, information storage and retrieval.

Neelamegam Soundararajan, Ph. D., (Bombay University). Appointed Autumn 1978.
Visiting Assistant Professor of Computer and Information Science. Theory of computation, semantics of programming languages, semantics of parallel processing.

Richard R. Underwood, Ph.D., (Stanford University).
Assistant Professor of Computer and Information Science. Numerical linear algebra, solution of large sparse systems of equations, eigenvalue analysis, linear least squares problems, numerical solution of differential equations.

Bruce W. Weide, Ph.D., (Carnegie-Mellon University). Appointed Autumn 1978.
Assistant Professor of Computer and Information Science. Analysis of algorithms, approximation algorithms, concrete computational complexity, computational geometry, parallel algorithms, probabilistic algorithms.

Stuart H. Zweben, Ph.D., (Purdue University).
Assistant Professor of Computer and Information Science. Programming languages, programming methodology, data structures, analysis of algorithms, systems programming.

Charles J. Shubra, Jr., M.S. (Pennsylvania State University). Appointed Summer 1978.
Visiting Instructor of Computer and Information Science. Database management, management information systems, programming methodology.

Ernest Staveley, B.S., (U.S. Naval Postgraduate School).
Administrative Assistant and Assistant Director, C.I.S. Research Center.

APPENDIX D

COMPUTER AND INFORMATION SCIENCE SEMINAR SERIES

July 7, 1977 "Design of Event-Driven Protection Mechanisms," David Cohen, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

July 14, 1977 "File Distribution Across I/O Subsystems and Networks," Lawrence Bowdy, Department of Computer Science, Duke University.

July 21, 1977 "Computer Operating Facilities for the Automatic Control and Activity Scheduling of Computer-Based Management Systems," Dov Isaacs, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

August 4, 1977 "The Development and Analysis of a Pragmatic Measure of Information in a Decision-Making Framework," Judith G. Abilock, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

August 18, 1977 "A Methodology for Computer Program Testing," Edward I. Cohen, Ph.D. Candidate, Department of Computer and Information Science, The Ohio State University.

August 23, 1977 "POREL: A Distributed Data Base on an Inhomogeneous Computer Network," Horst Biller, Institut fur Informatik, University of Stuttgart, West Germany.

September 29, 1977 "The Graduate Program in Biomedical Computing," Kevin C. O'Kane, Assistant Professor, Computer and Information Science and Assistant Professor, Allied Medicine, The Ohio State University.

October 6, 1977 "The IBM Series/I Mini Computer," Lee R. Bonneau, Series/1 Marketing Representative, IBM, Columbus, Ohio.

October 11, 1977 "The Human Interface to Microcomputers," Bruce Hamilton, Engineering Manager for Logic Development Products Group, Tektronix, Inc.

October 19, 1977 "Computer Crime Detection and Prevention," Donn B. Parker, Stanford Research Institute.

October 27, 1977 "BASIS and Machine-Independence of Software," Howard Turtle and Ken Szczesny, Battelle Columbus Laboratories.

November 3, 1977 "Research in Grammatical Inference (Or How to Play the Game 'Queries 'N' Theories')," Lee J. White, Associate Professor, Department of Computer and Information Science, The Ohio State University.

November 10, 1977 "Phrase Structure Syntax, Semantics, and Translation," H. William Buttelmann, Associate Professor, Department of Computer and Information Science, The Ohio State University.

November 17, 1977 "Computer Security," Douglas S. Kerr, Associate Professor, Department of Computer and Information Science, The Ohio State University.

November 18, 1977 "Control Structures for A. I. Programming Languages," William S. Havens, Computer Science Department, University of Tennessee.

January 12, 1978 "A Telephone Network Support System Using Unix," James Kaufeld, Member, Operating System Support Group, Bell Telephone Laboratories.

January 19, 1978 "Computer-Based Support of Strategic Planning," Clyde W. Holsapple, Visiting Assistant Professor of Management, Purdue University.

January 26, 1978 "Computer Generated Animation," Richard E. Parent, Research Associate, Computer Graphics Research Group, The Ohio State University.

February 1, 1978 "Certification and Professionalism in Computer Programming," William W. Cotterman, Chairman, Department of Information Systems, Georgia State University, Chairman, CCP Certification Council.

February 9, 1978 "Computer Networking at NSA," Howard A. Rumerman, Analyst, National Security Agency.

February 14, 1978 "The Impact of Inter-Process Communication on Distributed System Design," Robert L. Gordon, Senior Research Engineer, Research and Development, Prime Computer, Inc.

February 16, 1978 "Some Techniques for Improving Reliability and Maintainability of Computing Systems," Stephen S. Yau, Chairman, Department of Electrical Engineering and Computer and Information Science, Northwestern University.

February 23, 1978 "Superimposed Coding vs. Sequential and Inverted Files for Bibliographic Retrieval," Thomas Hickey, Research Associate, Ohio College Library Center.

February 28, 1978, "The Center," James Anderson, Computer Center Director, IBM-Kingston.

March 2, 1978 "An Overview of Leads," Don Cort, Data Systems Administrator, Department of Highway Safety, State of Ohio.

April 6, 1978 "Computer Networks," Marshall D. Abrams, Network Measurement Project Leader, Institute for Computer Science and Technology, National Bureau of Standards.

April 10, 1978 "Medical Systems Analysis Computers and Laboratory Medicine," Ralph R. Grams, M.D., Director of Medical Systems Analysis, University of Florida, Gainesville.

April 11, 1978 "Statistical Methods in Algorithm Design and Analysis," Bruce W. Weide, Carnegie-Mellon.

April 12, 1978 "Programming the IBM 5100: APL and BASIC," Cal Brostrum, General Systems Division, IBM Columbus.

April 13, 1978 "Computer Generated Animation," Richard E. Parent, Research Associate, Computer Graphics Research Group, The Ohio State University.

April 14, 1978 "Experimental Investigation of Programming Complexity," H. E. Dunsmore, Department of Computer Science, University of Maryland.

April 19, 1978 "When is a Computer Good Medicine," Josiah Macey, Director, Division of Biophysical Sciences, University of Alabama, Birmingham.

April 19, 1978 "Numerical Conformal Mapping," Charles Saltzer, Professor, Mathematics Department, The Ohio State University.

April 20, 1978 "The OSU Libraries On-Line Catalog System," Jean Yamauchi, Applications Programmer, University Systems, The Ohio State University and Betty Sawyers, Director, Health Sciences Library, The Ohio State University.

April 27, 1978 "The Role of Hypothetical Reasoning in Diagnostic Problem Solving," Harry E. Pople, Jr., Associate Professor of Business and Co-Director, Decision Systems Laboratory, University of Pittsburgh.

May 2, 1978 "Optimization by Collinear Scalings," William C. Davidon, Professor, Department of Physics, Haverford College, Pennsylvania.

May 4, 1978 "Distributed Computer Systems: The Potential Advantages and a Philosophy for Achieving Them," E. Douglas Jensen, Senior Principal Research Engineer/Scientist, Systems and Research Center, Honeywell.

May 11, 1978 "Automatic Generation of Computer Programs," Noah Prywes, Professor, Department of Computer and Information Science, Moore School of Electrical Engineering, University of Pennsylvania.

May 18, 1978 "Computer Based Education: Instructional Functions, Requirements, and Techniques," Keith A. Hall, Director, Computer Based Education, The Ohio State University.

May 25, 1978 "Ethical Issues in Artificial Intelligence," Joseph Weizenbaum, Professor of Computer Science, Massachusetts Institute of Technology.

APPENDIX E

RELATED ACTIVITIES OF THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

D. C. Brown presented a paper entitled "Representing Knowledge for a Natural Language Graphics System" (Co-author: B. Chandrasekaran) at the 1978 ACM Computer Science Conference, Detroit, Michigan, February 21-23, 1978.

J. S. Chandler was selected as one of four winners in the 1977 American Society for Information Science Doctoral Forum competition.

B. Chandrasekaran was an invited participant in a session on Multivariate Analysis during a meeting of the International Statistical Institute, New Delhi, India, December 9, 1977.

B. E. Flinchbaugh presented a paper entitled "Knowledge-Based Understanding of Dynamic Scenes" (Co-author: B. Chandrasekaran) at the 1978 ACM Computer Science Conference, Detroit, Michigan, February 21-23, 1978.

D. K. Hsiao was a member of the Program Committee, and was Session Chairman of the International Conference on Management of Data (SIGMOD), Toronto, Canada, August 3-5, 1977.

D. K. Hsiao presented a paper entitled "Data Base Machine Architecture in the Context of Information Technology Evolution" (Co-author: Stuart E. Madnick of M.I.T.) at the following locations: 3rd International Conference on Very Large Data Bases, Tokyo, Japan, October 14,1977; Academia Sinica, Taiwan, October 11, 1977; and Chung-Shan Research Institute, Taiwan, October 12,1977.

D. K. Hsiao presented a paper entitled "Structure Memory Designs for a Data Base Computer" at the 1977 National Association for Computing Machinery (ACM) Conference, Seattle, October 18, 1977.

D. K. Hsiao was a member of the Program Committee, and Session Chairman of the First IEEE Computer Society's Conference on Software and Application (COMPSAC), November 8-11, 1977.

D. K. Hsiao presented a lecture entitled "An Experiment in Data Base Access Control," (Co-presenter and co-author: Frank Manola of the Naval Research Laboratory) at COMPSAC '77 Conference, Chicago, Illinois, November 8, 1977.

D. K. Hsiao was a member of the Program Committee of the Fifth Annual Symposium of Computer Architecture, Palo Alto, California, February 1978.

D. K. Hsiao presented a lecture on "The Architecture of a Database Computer," at the following locations: IBM Research Laboratory, San Jose, California, May 5, 1977 (Co-presenter: Krish Kannan); Digital Techniques Laboratory, Sperry Research Center, Sudbury, Massachusetts, August 26, 1977 (Co-presenter: Krish Kannan); Battelle Memorial Institute, Columbus, Ohio, September 7, 1977; Digital Equipment Corporation, Maynard, Massachusetts, September 16, 1977 (Co-presenter: Krish Kannan); Tektronix Corporation, Beaverton, Oregon, September 24, 1977 (Co-presenter: Krish Kannan); PRIME Computer, Inc., Framingham, Massachusetts, September 28, 1977 (Co-presenter: Krish Kannan); Software Systems Division, OKI Electric Industry Co., Tokyo, Japan, October 6, 1977; Second Research Section of Computer Science Department, Fujitsu Laboratories, Ltd., Tokyo, Japan, October 6, 1977; Central Research Laboratories, Nippon Electric, Tokyo, Japan, October 7, 1977; Research and Development Center, Toshiba, Ltd., Tokyo, Japan, October 7, 1977; SRI International, Menlo Park, California, October 20, 1977; Department of Electrical Engineering, The Ohio State University, Columbus, Ohio, November 1, 1977; Honeywell Corporation, Minneapolis, Minnesota, November 3, 1977; Sperry Univac Corporation, St. Paul, Minnesota, November 4, 1977; Martin Marietta Aerospace Corporation, Orlando, Florida, November 18, 1977; TRW, Orlando Beach, Florida, December 1 and 2, 1977; Sperry Univac Corporation, Roseville, Minnesota, March 16, 1978; INTEL, Sunnyville, California, March 1978; and Memorex, Sunnyville, California, March 24, 1978.

D. S. Kerr presented a paper entitled "The Bachelor's and Master's Computer Science Graduate" (Co-author: Donald L. Kalmey) at a Poster Session of the Association for Computer Machinery's Special Interest Group on Computer Science Education, Detroit, Michigan, February 23-24, 1978.

D. S. Kerr presented a talk entitled "The Graduate Record Examination and Personal Self-Evaluation" at the East Region SIGCSE Conference, Denison University, Granville, Ohio, April 15, 1978.

M. J. Lee presented a paper entitled "Analysis and Evaluation of Structural Decision Systems" (Co-author: R. L. Ernst) at the 1978 ACM Computer Science Conference, Detroit, Michigan, February 21-23, 1978.

M. T. Liu was elected Chairman of the IEEE Computer Society, Columbus, Ohio Chapter, for 1977-78.

M. T. Liu presented an invited paper entitled "The Distributed Loop Computer Network (DLCN)" at The Second Distributed Processing Workshop, Brown University, Providence, Rhode Island, August 3-5, 1977.

M. T. Liu presented a paper entitled "A Performance Study of Distributed Control Loop Networks" (Co-authors: R. Pardo and G. Babic) at the 1977 International Conference on Parallel Processing, Bellaire, Michigan, August 23-26, 1977.

M. T. Liu presented an invited talk entitled "Research on the Distributed Loop Computer Network (DLCN)" at the Burroughs Corporation, Federal and Special Systems Group, Paoli, Pennsylvania, October 28, 1977.

M. T. Liu presented a talk entitled "Local Computer Networking" at the IEEE Computer Society, Columbus, Ohio Chapter, December 12, 1977.

M. T. Liu presented two papers entitled "A Performance Study of the Distributed Loop Computer Network (DLCN)" (Co-authors: G. Babic; R. Pardo) and "Distributed Services in Computer Networks: Designing the Distributed Loop Data Base System (DLDBS)" (Co-authors: G. Babic; R. Pardo) at the Computer Networking Symposium, Gaithersburg, Maryland, December 15, 1977.

S. A. Mamrak was the invited colloquium speaker and presented a paper entitled "Statistical Ranking and Selection Methods for Computer Comparisons" at the School of Information and Computer Science, Georgia Institute of Technology, November 17, 1977.

S. A. Mamrak presented a paper entitled "A Feature Selection Tool for Workload Characterization" (Co-author: P. Amer) at the 1977 SIGMETRICS/CMG VIII Conference, Washington, D.C., November 30, 1977.

P. D. Amer presented a paper entitled "The Application of Statistical Ranking and Selection Techniques to Computer Comparison Studies" (Co-presenter: S. A. Mamrak) at the 1978 ACM Computer Science Conference, Detroit, Michigan, February 21-23, 1978.

P. D. Amer presented a paper entitled "Statistical Methods in Computer Performance Evaluation: A Binomial Approach to the Comparison Problem" (Co-presenter: S. A. Mamrak) at the Computer Science and Statistics: Eleventh Annual Symposium on the Interface Conference, North Carolina State University, Raleigh, N.C., March 6-7, 1978.

H. H. Mei presented an invited talk entitled "Uncontrolled Optimization" at the following locations: Electro-Science Lab, Columbus, Ohio, November 15, 1977; and The University of Kentucky Numerical Analysis Lecture Series, Lexington, Kentucky, April 18, 1978.

R. E. Parent was selected as one of the four winners of the 1978 ACM Doctoral Forum.

A. E. Petrarca was elected Chairman and Program Chairman for the Central Ohio Chapter of the American Society for Information Science (COASIS), for 1978.

L. Rose presented a paper entitled "Information in Decision-Making" (Co-author: M.C. Yovits) at the 1978 ACM Computer Science Conference, Detroit, Michigan, February 21-23, 1978.

J. Rothstein presented a paper entitled "Toward an Arithmetic for Parallel Processing " at the 1977 International Conference on Parallel Processing, Bellaire, Michigan, August 23-26, 1977. This paper was voted "Most Original Paper" by the attendees of this conference.

J. Rothstein received the Best Paper Award for his paper entitled "On the Ultimate Limitations of Parallel Processing," which was presented at the 1976 International Conference on Parallel Processing. The award was presented to Professor Rothstein at the opening ceremonies of the 1977 International Conference on Parallel Processing, Bellaire, Michigan, August 23, 1977.

J. Rothstein presented the following two papers at the International Conference on Cybernetics and Society, Washington, D. C., September 19-21, 1977: 1) "Generalized Orthogonal Regression in Pattern Recognition" and 2) "Transitive Closure, Parallelism and the Modeling of Skill Acquisition."

J. Rothstein presented a paper entitled "Generalized Entropy, Boundary Conditions, and Biotonic Laws" at the Maximum Entropy Formalism Conference, M.I.T., Cambridge, Massachusetts, May 2-5, 1978. He was also a member of the panel discussing "Where is this field going?".

N. K. Sondheimer presented a talk entitled "Towards a Combined Representation for Spatial and Temporal Reference" at the 5th International Joint Conference on Artificial Intelligence, Cambridge, Massachusetts, August 22-25, 1977.

N. K. Sondheimer presented an invited talk entitled "Natural Language Understanding Systems and Model Theory" at Purdue University, West Lafayette, Indiana, February 23, 1978.

N. K. Sondheimer presented an invited talk entitled "Applying Concepts of Model Theory to Computer Understanding of Language" to The Ohio State University Semantics Group, Columbus, Ohio, May 3, 1978.

W. S. Stalcup was selected as one of the four winners in the 1977 American Society for Information Science Doctoral Forum competition.

W. S. Stalcup presented an invited talk entitled "Techniques for the Evaluation and Improvement of Automatic Vocabulary Control in Printed Indexes" at the Doctoral Forum, the 40th Annual Meeting of the American Society for Information Science, Chicago, Illinois, September 28, 1977.

R. R. Underwood presented a talk entitled "A Block Generalization of the Conjugate Gradient Method" at The Seventh Gatlinberg Conference on Numerical Linear Algebra, Monterrey, California, December 11-17, 1977.

L. J. White presented a talk entitled "Automatic Document Classification" (Co-presenter: S. Mittal) at the Annual Meeting of the Classification Society, Dartmouth College, Hanover, New Hampshire, June 7-9, 1977.

L. J. White presented an invited seminar on "Automatic Sequential Document Classification System" at the Department of Computer Science, Cornell University, November 17, 1977.

M. C. Yovits continues as an elected member of ACM Council, representing the East Central Region.

M. C. Yovits is an associate editor of the journal, Pattern Recognition.

M. C. Yovits was elected to another three year term on the Computer Science Board.

M. C. Yovits was chairman of the Biennial Meeting of Ph.D. Granting Computer Science Department Chairmen held at Snowbird, Utah, July 10-12, 1977.

M. C. Yovits gave a talk entitled "ACM and the Professional Computer Scientist" at a meeting of the Central Ohio Chapter of the Association for Computing Machinery, Columbus, Ohio, September 15, 1977, and at a meeting of the Pittsburgh Chapter of the Association for Computing Machinery, Pittsburgh, Pennsylvania, November 14, 1977.

M. C. Yovits presented a talk entitled "Opportunities in Computer Science - Jobs and Graduate Schools" to the student chapter of the Association for Computing Machinery and to Pi Mu Epsilon at Ohio Wesleyan University, Delaware, Ohio, February 16, 1978.

M. C. Yovits presented a talk entitled "Accreditation - A Perspective" at the East Central Region SIGCSE Conference, Denison University, Granville, Ohio, April 15, 1978.

M. C. Yovits presented a discussion entitled "National ACM and Current Issues of Interest to Local Chapter Members" to the Metropolitan Detroit Chapter of the Association for Computing Machinery, Warren, Michigan, June 13, 1978.

S. H. Zweben was coordinator of the ACM Regional Chapters Workshop, Columbus, Ohio, August, 1977.

S. H. Zweben was Co-advisor for The Ohio State Univeristy chapter of the Association for Computing Machinery (ACM), Columbus, Ohio, 1977-1978.

S. H. Zweben was appointed Chairman of the Workshop Planning Subcommittee of the Association for Computer Machinery's Committee on Chapters and chaired its session at the National Computer Conference, Anaheim, California, June 4, 1978.

S. H. Zweben presented a talk entitled "Science: Some Past, Present and Future Directions" at Dow Chemical, U.S.A., Midland, Michigan, December 13, 1977.

APPENDIX F

PUBLICATIONS OF THE DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE STAFF

BROWN, D.C.; KWASNY, S.C.; BUTTELMANN, H.W.; CHANDRASEKARAN, B.; SONDHEIMER, N. K. NLG -- Natural language graphics. In: Proceedings of the 5th International Joint Conference on Artificial Intelligence, M.I.T., Cambridge, Massachusetts, August, 1977, p. 916.

PYSTER, A; BUTTELMANN, H. W. Semantic-syntax-directed translation. Information and Control, Vol. 36, No. 3, March 1978.

KANAL, L. N.; CHANDRASEKARAN, B. On dimensionality and sample size in pattern recognition. In: Machine Recognition of Patterns, edited by A. K. Agrawala. IEEE Press, 1977, pp. 192-197. First published in Pattern Recognition, Vol. 3, 1971, pp. 225-234.

HARLEY, JR., T. J.; CHANDRASEKARAN, B. Comments on the mean accuracy of statistical pattern recognizers. In: Machine Recognition of Patterns, edited by A. K. Agrawala. IEEE Press, 1977, pp. 151-154. First published in IEEE Transactions on Information Theory, May 1969.

CHANDRASEKARAN, B. Independence of measurements and the mean recognition accuracy. In: Machine Recognition of Patterns, edited by A. K. Agrawala. IEEE Press, 1977, pp.155-159. First published in IEEE Transactions on Information Theory, Vol. 17, 1971, pp. 452-456.

CHANDRASEKARAN, B.; JAIN, A. K. Independence, measurement complexity and classification performance. In: Machine Recognition of Patterns, edited by A. K. Agrawala. IEEE Press, 1977, pp. 242-246. First published in IEEE Transactions on Systems, Man, and Cybernetics, March 1975.

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APPENDIX G

TECHNICAL REPORT SERIES

1968

YOVITS, M. C.; ERNST, R. L. Generalized information systems: Some consequences for information transfer. October, 1968. 47p. (OSU-CISRC-TR-68-1) (PB-180 929)

FILLMORE, C. J.; LEHISTE, I. Working papers in linguistics no. 2. November, 1968. 128p. (OSU-CISRC-TR-68-3) (PB-182 596)

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FINLEY, JR., M. R. The development of a basic language for artificial intelligence. January, 1969. 24p. (OSU-CISRC-TR-68-6) (PB-182 305)

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COLOMBO, D. S.; RUSH, J. E. Use of word fragments in computer-based retrieval systems. February, 1969. 7+[9]p. (OSU-CISRC-TR-69-1) (PB-184 104)

WHITE, L. J. Minimum covers of fixed cardinality in weighted graphs. March, 1969. 14p. (OSU-CISRC-TR-69-2) (PB-183 737)

JACKSON, D. M. The construction of retrieval environments and pseudo-classifications based on external relevance. April, 1969. 74p. (OSU-CISRC-TR-69-3) (PB-184 462)

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WHITE, L. J.; RUSH, J. E. Linear lists for spiro graphs. June, 1969. 69p. (OSU-CISRC-TR-69-6) (PB-194 402)

PETRARCA, A. E.; LAY, W. M. The double KWIC coordinate index. A new approach for preparation of high-quality printed indexes by automatic indexing techniques. April, 1969. 12 +[17]p. (OSU-CISRC-TR-69-7)*

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YOVITS, M. C. Information science: Toward the development of a true scientific discipline. June, 1969. 27p. (OSU-CISRC-TR-69-8) (PB-187 983)

PETRARCA, A. E.; LAY, W. M. The double KWIC coordinate index. II. Use of an automatically generated authority list to eliminate scattering caused by some singular and plural main index terms. August, 1969. 13p. (OSU-CISRC-TR-69-9)*

MCCULLOUGH, J. L. The acquisition of information across cultures: I. Persuasive role play, counterargument and attitude change. August, 1969. 18p. (OSU-CISRC-TR-69-10) (PB-197 568)

ERNST, R. L.; YOVITS, M. C. Information science as an aid to decision making. September, 1969. 22p. (OSU-CISRC-TR-69-13) (PB-189 666) (ED-054 782)

LANDRY, B. C. An indexing and re-indexing simulation model. June, 1969. 50p. (OSU-CISRC-TR-69-14) (PB-198 115)

SALVADOR, R. Automatic abstracting and indexing. June, 1969. 93p. (OSU-CISRC-TR-69-15)

STEVENS, D. W. A computer program for the reduction of flow tables. June, 1969. 97p. (OSU-CISRC-TR-69-16) (PB-189 679)

COLOMBO, D. S. Automatic retrieval systems and associated retrieval languages. 1969. 69p. (OSU-CISRC-TR-69-17) (PB-198 116)

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DAY, R. G.; WHITE, L. J. Study of a random search method for function minimization. March, 1970. 77p. (OSU-CISRC-TR-70-6) (PB-194 404)

PHARES, R.; WHITE, L. J. Identification of circuits in chemical structures. June, 1970. 73p. (OSU-CISRC-TR-70-7) (PB-194 396)

HARALSON, K. M.; WHITE, L. J. Optimal prefix codes for ensembles of N equiprobable messages using a binary alphabet. May, 1970. 105p. (OSU-CISRC-TR-70-8) (PB-197 642)

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LYONS, J. J. The speed-accuracy trade-off in processing different classes of material. 1970. 38p. (OSU-CISRC-TR-70-11) (PB-198 114)

FILLMORE, C. J.; LEHISTE, I.; MELTZER, D.; TATHAM, M. A.; THOMPSON, S. A. Working papers in linguistics no. 6. September, 1970. 132p. (OSU-CISRC-TR-70-12) (PB-194 829)

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JACKSON, D. M. Basis for an improvability measure for retrieval performance February, 1970. 31p. (OSU-CISRC-TR-70-25) (PB-197 812)

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WHITTEMORE, B. An example of the application of generalized information systems concepts to the quantification of information in a decision system: The examination of quantified information flow in an industrial control problem. May, 1971. 51p. (OSU-CISRC-TR-71-4) (PB-202 621)

OSTROM, T. M.; STEELE, C. M.; SMILANSKY, J. Information and attitudes: The effects of information context and perceived discrepancy on attitudes. May, 1971. 23p. (OSU-CISRC-TR-71-5) (PB-202 622)

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MELTZER, D. Speech synthesis by haar functions with comparison to a terminal analog device. January, 1972. 135p. (OSU-CISRC-TR-72-2)

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